Reliability of Bedside Evaluation in Determining Left Ventricular Function: Correlation With Left Ventricular Ejection Fraction Determined by Radionuclide Ventriculography

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Ninety-nine patients with chronic coronary artery disease were prospectively evaluated to determine the reliability of historical, physical, electrocardiographic and radiologic data in predicting left ventricular ejection fraction. The left ventricular ejection fraction measured by radionuclide angiography was normal (≥50%) in 44 patients (group 1) and abnormal (<50%) in 55 patients; 36 of those 55 patients had an ejection fraction between 30 and 49% (group 2) and the remaining 19 patients had an ejection fraction of less than 30% (group 3).

The ejection fraction was correctly predicted in 33 of the 44 patients (75%) in group 1 and in 47 of the 55 patients (85%) with abnormal ejection fraction (groups 2 and 3), but the degree of ventricular dysfunction was correctly predicted in only 19 patients (53%) in group 2 and in only 9 patients (47%) in group 3. Stepwise linear regression analysis was performed. The single most predictive variable was cardiomegaly as seen on chest roentgenography (R^2 = 0.52). Four optimal predictive variables—cardiomegaly, myocardial infarction as seen on electrocardiography, dyspnea and rales—could explain only 61% of the observed variables in left ventricular ejection fraction. Thus, radionuclide ventriculography adds significantly to the discriminant power of the clinical, radiographic and electrocardiographic characterization of ventricular function in patients with chronic coronary heart disease.

In the practice of cardiology and medicine, expensive, uncomfortable and even risky procedures are performed to establish a diagnosis when a thorough medical history and physical examination might suffice. Electrocardiograms and chest X-ray films may provide additional important information to determine the anatomic diagnosis and, at times, the degree of functional impairment of the heart.

Quantitative and qualitative assessment of left ventricular function is an important prognosticator in patients with coronary heart disease. Furthermore, it may be a useful index for appropriate therapy. In the past, determination of left ventricular ejection fraction was limited to invasive testing with contrast left ventriculography (1), but now ejection fraction can be measured by radionuclide angiography (2,3) or echocardiography (4). Despite a plethora of data concerning the importance of left ventricular ejection fraction, there are few published reports concerning the accuracy of bedside evaluation combined with the electrocardiogram and chest X-ray films in predicting left ventricular function. This study was undertaken to determine the value and limitations of historical, physical, electrocardiographic and X-ray data in predicting left ventricular ejection fraction in patients with chronic coronary heart disease.

Methods

Study patients. The patient population in this prospective study comprised 99 consecutive patients with suspected or proved coronary heart disease who underwent radionuclide angiography for the evaluation of left ventricular function in our laboratory. There were 65 men and 34 women, whose ages ranged between 32 and 82 years (mean 57). Patients with acute myocardial infarction or valvular heart disease were excluded. Thirty-five patients had had previous myocardial infarction (at least 6 months before the study) defined by characteristic Q waves, 40 ms wide or more, in precordial leads for anterior infarction, and in leads III and aVF for inferior infarction.

A complete history was recorded and physical examination was performed by a cardiologist before the radionuclide angiographic study. The examiner was requested to predict the left ventricular ejection fraction in each patient as normal (≥50%), mild to moderately reduced (30 to 49%) or severely reduced (<30%). The

From the Likoff Cardiovascular Institute of Hahnemann University, Philadelphia, Pennsylvania. Manuscript received July 18, 1982; revised manuscript received August 31, 1982, accepted September 8, 1982.

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0735-1097/83/020417-4$03 00

examiner was unaware of the results of radionuclide angiography because these tests were performed later. The chest X-ray films and electrocardiograms were obtained and interpreted within 48 hours of the radionuclide study in most patients.

Variables used to predict left ventricular ejection fraction included the following: age and sex of the patient; presence and severity of angina pectoris and dyspnea according to the New York Heart Association functional classification (5); history of previous myocardial infarction; presence of enlarged heart observed on physical examination, as indicated by displacement of the apical impulse, lateral and inferior to the midclavicular line at the fifth intercostal space; S_3 gallop; a mitral regurgitation murmur; bibasilar rales; Q waves diagnostic of previous infarction, as defined earlier, and roentgenographic evidence of cardiac enlargement (cardiothoracic ratio ≥50%) or pulmonary congestion (Table 1).

Radionuclide ventriculography. The left ventricular ejection fraction was measured by first pass radionuclide ventriculography with a computerized multicrystal gamma camera (Baird-Atomic Systems-77) equipped with a 1 inch (2.5 cm) parallel hole collimator positioned anterior to the precordium. The radionuclide angiograms were analyzed with computer software incorporated into the system. The left ventricular ejection fraction was determined from the background-corrected representative cardiac cycle as follows:

$$\frac{\text{End-diastolic counts} - \text{End-systolic counts}}{\text{End-diastolic counts}} \times 100.$$

The technique has been previously described by this and other laboratories (2,3).

Statistical analysis. Stepwise linear regression was performed with the use of the statistical application for the social sciences program (SAS) on the variables listed in Table 1, to identify the best predictors of left ventricular ejection fraction. Analysis of variance was used to compare differences among groups of patients. The chi-square test was used to compare the differences between the predicted and actual left ventricular ejection fraction. A probability (p) value of less than 0.05 was considered significant.

Results

Sixty patients had angina pectoris; 25 were in functional class I or II and 35 were in class III or IV (Table 1). Seventy-nine patients had mild or no functional limitations related to dyspnea (class I or II); 20 patients were severely limited by dyspnea (class III or IV). A history of previous myocardial infarction was obtained in 46 patients, and 35 patients had Q waves on electrocardiography diagnostic of a prior transmural infarction. Physical examination revealed an enlarged heart in 18 patients and bibasilar rales in 14. Chest X-ray study results showed cardiomegaly in 42 patients and pulmonary congestion in 24.

Measured and predicted left ventricular ejection fraction. The mean left ventricular ejection fraction as determined by radionuclide angiography for the entire group was 45% (range 10 to 85). Patients were classified into three groups according to the measured ejection fraction: group 1 comprised 44 patients with an ejection fraction of 50% or greater; group 2 comprised 36 patients with an ejection fraction between 30 and 49%; and group 3 comprised 19 patients with an ejection fraction of less than 30%. The distribution of the variables in relation to the ejection fraction is shown in Table 1. Most patients with dyspnea (class III or IV), a history of infarction, rales, enlarged heart by physical examination, S_3 gallop, electrocardiographic evidence of prior infarction, enlarged heart by chest X-ray examination and pulmonary congestion by chest X-ray studies had an abnormal ejection fraction.

In group 3, the ejection fraction was correctly predicted in 9 patients (47%); in the remaining 10 patients, the ejection fraction was predicted to be 30 to 49%. None of these patients, however, was predicted to have a normal ejection fraction. *In group 2,* the ejection fraction was correctly

Table 1. Clinical, Electrocardiographic and Chest X-ray Findings

	Group 1 (n = 44) (no. of pts)	Group 2 (n = 36) (no. of pts)	Group 3 (n = 19) (no. of pts)	p Value
Angina pectoris (NYHA)				
Class I, II	10 (23%)	11 (31%)	4 (21%)	NS
Class III, IV	13 (30%)	15 (42%)	7 (37%)	NS
Dyspnea on exertion (NYHA)				
Class I, II	39 (89%)	29 (81%)	11 (58%)	0.0003
Class III, IV	5 (11%)	7 (19%)	8 (42%)	0.0003
History of MI	11 (26%)	23 (64%)	12 (63%)	0.0005
Rales	1 (2%)	6 (17%)	7 (37%)	0.001
Displaced apical impulse	1 (2%)	9 (25%)	8 (42%)	0.0002
Mitral regurgitation	5 (11%)	8 (22%)	6 (32%)	NS
S_3 gallop	5 (11%)	11 (31%)	13 (68%)	<0.0001
MI by electrocardiogram	7 (16%)	17 (47%)	11 (58%)	<0.0001
Cardiomegaly by chest X-ray	3 (7%)	21 (58%)	18 (95%)	<0.0001
Pulmonary congestion by chest X-ray	3 (7%)	9 (25%)	12 (63%)	<0.0001

MI = myocardial infarction; n = number of patients; NS = not significant; NYHA = New York Heart Association classification; p = probability, pts = patients

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1983;1(2) 417–20

predicted in 19 patients (53%). Of the remaining patients, nine were predicted to have an ejection fraction of less than 30% and eight were predicted to have an ejection fraction of 50% or greater. *In group 1*, the ejection fraction was correctly predicted in 33 patients (75%). The remaining 11 patients were predicted to have an ejection fraction of 30 to 49%. None of these patients was predicted to have an ejection fraction of less than 30% (Fig. 1).

Therefore, bedside evaluation correctly predicted a normal ejection fraction in 33 of the 44 patients (75%) whose ejection fraction measured by radionuclide angiography was normal (group 1). Similarly, of the 55 patients with a measured abnormal ejection fraction (groups 2 and 3), bedside evaluation correctly predicted the ejection fraction in 47 patients (85%). The overall predictive accuracy was 81% (80 of the 99 patients).

The presence of cardiomegaly on chest X-ray study was the single best predictor of ejection fraction (R^2 = 0.52; Table 2). As determined by multivariant stepwise regression analysis, the combination of cardiomegaly determined by chest X-ray study and electrocardiographic evidence of prior transmural infarction, dyspnea and rales improved the correlation slightly (R^2 = 0.61; Table 3, Fig. 2).

Discussion

Clinical evaluation has been useful in categorizing patients with acute infarction according to the degree of hemodynamic decompensation (6). Riley et al. (7) found that in patients with acute infarction, an S_3 gallop occurs almost exclusively in those with elevated left ventricular filling pressure. Nevertheless, several studies (8,9) have indicated that an abnormal left ventricular ejection fraction, sometimes of a severe degree, may occur even without abnormal physical signs or symptoms in these patients. In patients with chronic coronary heart disease, deterioration in left ventricular function results from myocardial scarring due to infarction. Elevation of the left ventricular filling pressure in these patients, whether due to increased stiffness of the left ventricle or left ventricular dilation, or both, may occur and will be aggravated by episodes of myocardial ischemia such as those induced by physical activity (10). However, the hemodynamic abnormalities are variable and may be modified considerably by therapeutic intervention (11). The abnormalities in left ventricular function are responsible for abnormal physical signs (cardiomegaly, S_3 gallop, murmur of mitral regurgitation, basilar rales), symptoms of congestive heart failure, abnormal chest X-ray findings (cardiomegaly or pulmonary congestion) and electrocardiographic abnormalities consistent with infarction.

Figure 1. Correlation between measured and predicted ejection fractions in 99 patients.

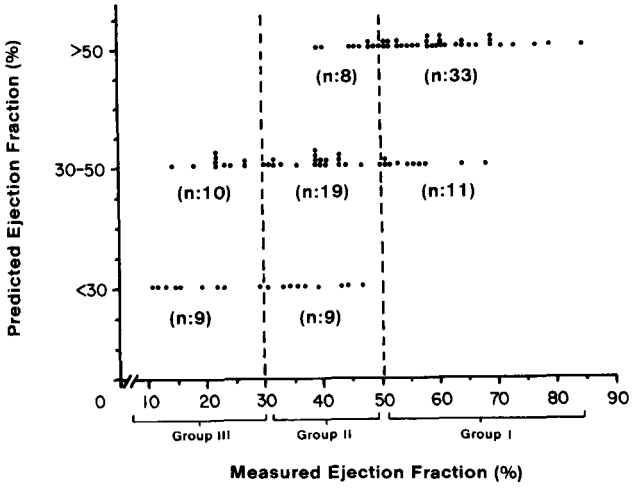

Table 2. Correlation Matrix of Variables Used to Predict the Ejection Fraction

Variable	Matrix
Angina	R^2 = 0.02
Dyspnea	R^2 = 0.19
MI by history	R^2 = 0.14
Rales	R^2 = 0.14
Displaced apical impulse	R^2 = 0.18
Mitral regurgitation	R^2 = 0.03
S_3 gallop	R^2 = 0.24
Q wave MI	
Anterior	R^2 = 0.14
Inferior	R^2 = 0.05
Cardiomegaly by chest X-ray	R^2 = 0.52
Pulmonary congestion by chest X-ray	R^2 = 0.24

MI = myocardial infarction.

Clinical variables predictive of ejection fraction. Palmeri et al. (12) evaluated the 12 lead electrocardiogram and computed a scoring system that takes into consideration the height and the width of the R and S waves. They found that this electrocardiographic scoring system is useful in predicting left ventricular ejection fraction in patients with acute infarction. However, our own data (13), although confirming their observations in patients with acute infarction, have

Table 3. Summary of Multiple Regressions of Independent Variables Used to Predict Ejection Fraction With Stepwise Regression Coefficients

Step	Variable Entered	Multiple Regression	No. of Independent Variables Included
1	Cardiomegaly by chest X-ray	R^2 = 0.52	1
2	Q wave MI	R^2 = 0.56	2
3	Dyspnea	R^2 = 0.59	3
4	Rales	R^2 = 0.61	4

MI = myocardial infarction.

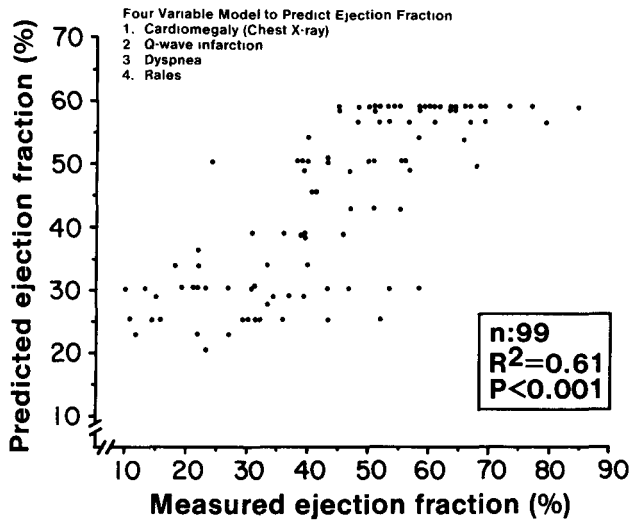

Figure 2. Predicted versus measured ejection fraction in 99 patients by means of a 4-variable model.

shown that this scoring system is not useful in patients with chronic infarction.

Sanford et al. (9) examined 13 variables derived from historical, physical, electrocardiographic and radiologic data in patients with acute infarction, and found the six most predictive variables ranking in decreasing order of importance to be: 1) anterior, transmural or subendocardial infarction; 2) abnormal chest X-ray results; 3) rales; 4) previous infarction; 5) transmural infarction; and 6) heart rate greater than 100 beats/min. These investigators, by using stepwise regression analysis, found that even these six optimal predictive variables could explain only 42% of the observed variability in left ventricular ejection fraction.

Our results indicated that a synthesis of historical, physical, electrocardiographic and X-ray data can predict left ventricular ejection fraction as normal or abnormal in 81% of patients with chronic coronary heart disease. However, the degree of left ventricular dysfunction was correctly predicted in only 28 of 55 patients with abnormal left ventricular function (Fig. 1). It should be noted that no patient with a normal ejection fraction as measured by radionuclide angiography was predicted to have severe left ventricular dysfunction; likewise, no patient with severe left ventricular dysfunction by radionuclide angiography was predicted to have a normal ejection fraction.

We found that cardiomegaly on chest X-ray study was the best predictor for ejection fraction (R^2 = 0.51; Table 2). We also found that four optimal predictive variables (cardiomegaly by chest X-ray study, transmural infarction by electrocardiogram, dyspnea and rales) could explain only 61% of the observed variability in left ventricular ejection fraction (Fig. 2).

Clinical implications. This study emphasizes that the traditional methods for patient evaluation are reliable in predicting ejection fraction as normal or abnormal in most patients (81%). For many clinicians, this level of probability is sufficient to guide recommendation and management. However, the precise degree of left ventricular dysfunction was correctly identified in only half of the patients. Radionuclide ventriculography thus adds significantly to the discriminant power of the clinical, radiographic and electrocardiographic characterization of ventricular function in patients with chronic coronary heart disease.

We thank Wanda Klein for her secretarial assistance; Edith Schwager, the editor; and members of the Cardiovascular Institute and the Department of Nuclear Medicine for their participation in this study.

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